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PLANTING SEASON FOR SUGAR BEETS IN CENTRAL CALIFORNIA¹

KATHERINE ESAU²

INTRODUCTION

The climate is one of the most important factors in determining the suitability of a given area for sugar beet culture. The sugar beet requires a long growing period and is greatly influenced in its development by the distribution of heat during its growth. It thrives best when the earlier period of its growth comes during the cooler part of the year and the plant is therefore adapted to the temperate regions.

In states where the winter months are cold, beets are not planted until about April, when the weather becomes warmer and the danger of heavy frosts has passed. In such localities the growing season is comparatively short, and in some years the beets do not mature properly. The thinning and harvesting operations are, furthermore, crowded into a brief space of time.

California, with its equable temperature, has the advantage that the seeding can be done during the greater part of the year. This fact gives the grower an opportunity to extend the growing period and, by selecting the proper time of seeding, to give the plant optimum conditions of growth. By extending the planting time, moreover, the California grower can distribute the thinning and harvesting operations more favorably than the growers in other states, who have only a short period of favorable planting weather.

Although the beet planting season is long in California, the seedings made during different months do not produce equally good yields. Experimental data collected at Davis, California, a station representative of Sacramento Valley, and observations in commercial fields in the San Joaquin, Sacramento, Salinas, and San Juan valleys will serve as a basis for the following discussion of the best time to plant sugar beets in central California.

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EXPERIMENTS TO DETERMINE BEST TIME OF PLANTING

The time-of-planting tests were conducted during four consecutive seasons, 1927–1931, upon a typical Yolo loam soil. Seed was planted every month, from November to March. During two years the plantings were extended until April and once a planting was done in October. The February planting of 1929 was lost through crust formation and seed was replanted on March 12. During the first three years, the seed was planted in level ground in rows spaced 20 inches apart. In 1931 the planting was made upon ridges by spacing two rows 16 inches apart upon each ridge and leaving 24 inches between the two rows on two adjacent ridges. The ridges were 5 inches in height after the soil had settled. Wherever possible, the beets were spaced one foot apart in the rows. The number of replications were three in 1928, four in 1929, and five in 1930 and 1931. The size of the plots was 1/50 acre in 1928 and 1929, and 1/100 acre in 1930 and 1931. The irrigation water was given approximately every 14 days, in total 5 to 6 irrigations, and at the end of the season the plants were left for three weeks without further irrigation. The soil was cultivated with hand cultivators. All plantings each year were harvested on the same date, but in different years the harvest was gathered at somewhat different dates—in every case, however, at the time when the commercial harvest was well under way. The late beets could have been left longer in the ground than the early beets, and with additional amounts of irrigation water they would presumably have continued to grow and increase in size somewhat. Under commercial conditions late beets do not always receive an additional supply of water in the latter part of the season, especially in years when there is a shortage of irrigation water. Under such conditions late beets would not grow much during the latter part of the season when temperatures are usually highest. Moreover, late beets are more severely affected with curly top than early beets and even under favorable moisture conditions such beets do not make much additional growth during late summer and fall. The commercial seed, Rabbethge and Giesecke's "Old Type," was used in all tests with the exception of that of 1930, when the Rabbethge and Giesecke's "Pioneer" seed was sown. Curly top was present every year and affected most severely the March and April plantings.

Table 1 gives the results obtained in these trials. Although somewhat different cultural practices were used in different years (ridge vs. usual planting, and two varieties of seed) the results are con-

TABLE 1
TIME-OF-PLANTING TESTS OF 1927-1931, DAVIS, CALIFORNIA

Date of planting	Number of beets harvested per 100 feet of row	Percentage of bolters	Average weight per beet, pounds	Percentage of sugar	Yield of roots, tons per acre	Yield of sugar, pounds per acre
1927-28						
November 17.....	56	52.0	3.2	14.1	23.4	6,599
December 15.....	63	29.0	3.0	15.8	24.7	7,805
January 14.....	102	3.0	2.5	18.7	34.0	12,716
February 15.....	89	0.0	2.6	17.8	29.7	10,573
March 14.....	100	0.0	2.2	17.0	28.4	9,656
April 13.....	80	0.0	1.6	17.2	17.0	5,848
1928-29						
November 20.....	62	44.4	3.3	15.2	26.9	8,178
December 17.....	73	31.0	3.1	14.8	29.8	8,821
January 18.....	88	1.8	2.7	15.5	30.9	9,579
February 19.....	109	0.0	2.0	17.0	29.2	9,928
March 19.....	99	0.0	1.5	16.5	19.2	6,336
1929-30						
November 23.....	100	61.0	1.6	14.8	21.4	6,334
December 23.....	92	37.0	1.7	15.3	20.0	6,120
January 23.....	108	0.5	2.2	16.5	31.1	10,263
March 12.....	108	0.0	1.5	16.2	21.1	6,836
March 22.....	106	0.0	1.4	14.5	19.4	5,626
April 16.....	103	0.0	0.8	17.5	11.4	3,990
1930-31						
October 16.....	107	30.2	2.4	17.3	33.6	11,626
November 18.....	96	16.6	2.2	17.9	28.1	10,060
December 15.....	95	8.0	2.3	19.2	28.3	10,867
January 15.....	102	0.5	2.0	18.3	26.9	9,845
February 17.....	104	0.0	1.6	18.1	21.2	7,674
March 14.....	101	0.0	1.3	18.2	17.4	6,334
Average of 4 years						
November.....	79	43.5	2.5	15.6	25.0	7,793
December.....	81	26.2	2.5	16.3	25.7	8,403
January.....	100	1.5	2.3	17.3	30.7	10,601
February.....	103	0.0	2.0	17.2	26.6	9,175
March.....	102	0.0	1.6	16.6	21.1	6,988
April*.....	92	0.0	1.2	17.3	14.2	4,919

* Average of two years.

sistent throughout in the respect that they indicate a superiority on the part of the early plantings. This table also shows that the yields are in general much higher than in commercial fields; but this fact is explained by a uniform stand, good soil, good cultural conditions, and an abundant supply of water.

For the purpose of correlating some of the data obtained from the various plantings with the temperature conditions during the growing seasons, the mean monthly temperatures at Davis during 1927–1931 are given in figure 1. The temperature descends rather abruptly from October until the early part of January, then rises again. The coldest months are December and January.

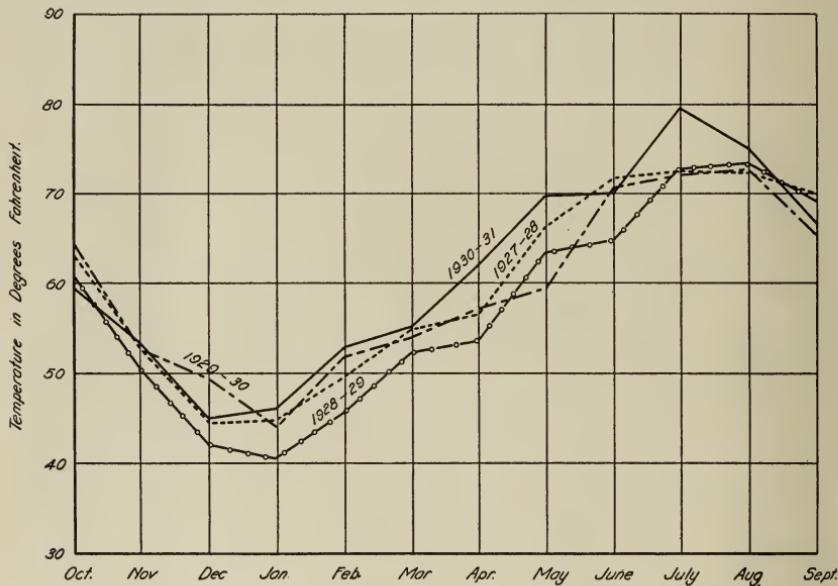


Fig. 1.—Mean monthly temperatures at Davis, California, 1927–1931.

The early plantings, November to February, produced, as a rule, higher yields of roots and sugar than later plantings, March and April. This difference resulted mainly from the heavier roots in early beets. The percentage of sugar in the very early beets was comparatively low, but was more than compensated for by the yield per acre of roots when compared with the latest plantings.

November to February were evidently more favorable months for planting than March and April, but there were also differences within the group of early plantings. During two years out of four, the January beets produced the highest yield of sugar per acre; and during one year the February beets gave most sugar. January and February beets have the tendency to produce heavy roots with a high percentage of sugar. The November beets tested lower than those of January and February, in all four seasons, and the December beets in three seasons out of four. The October planting, which was

tested only once, gave good results. As will be pointed out later, however, October is not a safe month for planting on account of the danger of curly-top infection.

The beets of October, November, and December showed a high percentage of bolters, that is, of beets that produced seed stalks during the first year of growth. The earlier the planting, the more seed stalks appeared in the plots (table 1). The percentage of bolters varied from season to season and was lowest in 1930-1931, a year with the highest average temperature for the season (table 1 and fig. 1).

In two seasons the stand of beets in the November and December plantings was reduced by attacks of damping-off fungi. This accounts for the low number of beets per 100 feet of row and for their large average size in these two plantings. There was a considerable variation in the time required for germination in the different months of planting. In 1930-1931 the December-planted seed required a month for germination; November, January, and February plantings required about two weeks; March and October plantings required one week at optimum moisture conditions. This difference stands in relation to temperatures which is clearly indicated in figure 3.

To satisfy scientific readers the data obtained from the various plantings were analyzed according to Bessel's method of calculating probable errors of means. As there were several replications every year and the data from each replication served as one observation, the total number of observations in each group of plantings was 17. The early plantings, November to February inclusive, gave $9,290 \pm 267.9$ pounds per acre of sugar, whereas the March plantings gave $6,771 \pm 282.3$, that is, there was an increase of $2,519 \pm 389.2$ pounds per acre in the early as compared with the late plantings. January beets taken separately gave $10,405 \pm 280.1$ pounds per acre, which means an increase of $3,634 \pm 397.7$ pounds per acre in comparison with the March plantings.

OBSERVATIONS IN COMMERCIAL FIELDS

Observations in commercial fields have also shown that better crops are obtained from early-planted beets. Some data on the effect of date of planting which were collected in Yolo County on muck type of soil are given in table 2.

In 1925 there were only late beets, and as it was a year of an exceptionally severe outbreak of the curly-top disease, a very low tonnage was obtained throughout the district. In 1926 plantings

were made in December, January, March, and April. Curly-top attack was severe, although less so than in 1925. The late beets gave comparatively low yield, whereas the early beets, in particular those of the January planting, gave a fairly high tonnage. Although the outbreak was mild in 1927, the January beets gave a far better yield than the March and April beets. The December planting, however, was not successful as it produced about 70 per cent bolters and gave a low tonnage.

TABLE 2

EFFECT OF TIME OF PLANTING UPON YIELD OF COMMERCIALLY GROWN
SUGAR BEETS IN YOLO COUNTY
(Data from Spreckles Sugar Company)

Year and date of planting	Number of acres	Yield of roots, tons per acre	
1925 March 1 to June 13.....	1,668	5.15	
1926 { December 12 to 19.....	105	13.43	
	January 2 to 30.....	488	15.11
	March 13 to April 3.....	327	8.04
1927 { December 11 to 31.....	299	8.20	
	January 1 to February 12.....	377	21.17
	March 19 to April 16.....	145	12.39

Severe injury by curly top is not the only difficulty that may be encountered in late plantings of sugar beets. It is frequently difficult to obtain good stands in the spring and early summer because of lack of moisture. Dry winds and high temperatures may be injurious to the young plants, especially during thinning time.

In the case of the early-planted beets, on the other hand, there is abundant supply of moisture for the germination of the seed and the plants make the major part of their growth during the cool weather. They utilize the winter moisture to a greater extent than the late beets. Early-planted beets are comparatively large at the time when climatic conditions permit the most rapid growth (spring and early summer) and they take the fullest advantage of these conditions, so that their rate of increase at this time is higher than that of the still small late-planted beets. Early beets have a long growing season which favors development of heavy roots. When beets are planted early there is more time available for reseeding in the case of stand failures.

In general, the plantings made from November to February are safer than those made in March, and later, in central California.

Considering separately the plantings of late fall (November to early December) and those of winter (late December, January, February), experience has shown that January and February are, as a rule, more favorable months for planting sugar-beet seed than November and early December.

A number of difficulties may be encountered in planting during the late fall. It is sometimes more difficult to obtain a good stand in November and early December than during winter. As the soil becomes cold in November and the temperature continues to fall, the seed germinates slowly and there is danger of the seed rotting in the ground or of the young seedlings drowning out during wet seasons. Moreover, fall rains are frequently followed by strong winds and clear days, so that the surface of the soil dries off rapidly and a crust is formed before the seedlings have time to emerge. Beet seedlings are not very efficient in breaking through a hardened soil surface and for this reason seedlings that are retarded by low temperatures from penetration to the surface are weakened and killed when crust formation occurs. An uneven or a very poor stand is the result of this condition. The crust varies in nature, depending on the type of soil and the conditions of the weather. If the crust is thin and the plants are not yet up, harrowing or rolling will remedy the situation; but, if the crust is thick, and especially if plants are caught in this crust, the only thing to do is to replant because any cultural operation will tear the plants up. Stands may be materially reduced also by the attacks of damping-off fungi whose development is favored in cold, wet, poorly aerated soils. Young sugar beets can stand fairly low temperatures and frosts usually do not kill the plants which are above the surface. Experience has shown, however, that occasionally young seedlings that are just emerging above the surface and are surrounded by wet soil may be destroyed by frost.

Better stands are frequently obtained with beets that are planted in January and February. The seed germinates more rapidly because after the middle of January the temperature begins to rise and there is less danger of injury through crust formation.

November and December beets are subject to more severe infection with the downy mildew of beet³ than later plantings because the fungus causing this disease spreads most rapidly during late fall.

The early November plantings which come up before the rainy season begins have been known to be destroyed by birds in some localities.

³ Leach, L. D. Downy mildew of the beet, caused by *Peronospora schachtii* Fuckel. *Hilgardia* 6:203-251. 1931.



Fig. 2.—A commercial sugar beet field in Yolo County showing 70 per cent of bolters.

TABLE 3

RAINFALL DATA FOR THE MONTHS, NOVEMBER TO FEBRUARY, 1911-1930,
DAVIS, CALIFORNIA

Year	Total rainfall for month, inches				Number of rainy days				Maximum for any one day, inches			
	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.
1911	0.12	1.13	13.08	1.79	2	7	17	10	0.08	0.36	2.95	0.48
1912	1.08	0.33	2.08	0.20	5	2	13	3	0.74	0.17	0.49	0.11
1913	4.63	7.44	3.43	0.15	11	13	9	2	1.74	3.35	0.18	0.15
1914	0.16	4.75	9.17	4.35	2	15	15	6	0.09	0.95	1.35	1.52
1915	0.53	6.03	4.62	5.01	4	6	15	14	0.27	3.05	1.01	0.97
1916	0.35	4.81	11.01	1.93	4	11	20	9	0.18	1.33	3.93	0.55
1917	0.12	0.59	1.28	5.90	3	3	4	9	0.08	0.44	0.93	2.93
1918	2.19	1.69	0.95	3.59	5	4	2	12	0.94	0.48	0.55	0.81
1919	0.31	2.61	2.49	7.12	2	8	8	12	0.28	0.95	1.18	2.13
1920	4.02	4.39	0.37	0.76	10	14	2	5	0.80	1.00	0.26	0.34
1921	1.62	4.39	5.11	0.32	4	10	9	2	0.80	1.54	1.68	0.20
1922	3.29	7.37	2.29	5.85	4	17	3	11	1.10	1.10	0.96	1.40
1923	0.53	0.88	2.62	0.70	2	4	6	4	0.32	0.36	0.84	0.25
1924	1.42	3.55	2.46	2.76	5	12	5	4	1.17	1.00	1.48	1.15
1925	1.71	1.29	1.05	4.28	7	4	4	13	1.02	0.43	0.80	0.83
1926	5.18	0.73	3.70	5.50	14	7	8	10	1.54	0.25	1.28	2.03
1927	2.91	2.32	2.18	4.66	10	8	14	18	0.56	0.95	0.42	0.88
1928	3.19	2.74	1.73	1.62	5	7	9	7	1.67	0.85	1.02	0.55
1929	0.09	3.77	0.63	1.56	1	8	6	5	0.09	1.21	0.28	0.64
1930	0.92	0.20	3.80	1.66	5	1	11	7	0.34	0.20	0.76	0.50
Average	1.72	3.05	3.70	2.99	5	8	9	8	0.69	1.00	1.12	0.92

November and December plantings usually show a high percentage of beets that go to seed prematurely (bolters), whereas beets that are planted in January or later show few or no bolters. Figure 2 shows a commercial field in Yolo County which was planted in November, 1926, and showed 70 per cent bolters at harvest in August, 1927.

The question of possible interference of rains with planting operations has been considered. Table 3 gives rainfall data obtained at the Davis station for the months of November, December, January, and February for a period of 20 years. The four months indicated previously as being favorable for planting beet seed are the rainiest months of the year. In seasons of heavy precipitation the land will be too wet for the proper execution of planting operations. One can readily see, however, that during 20 years only a few times was the precipitation so heavy during the winter months that it could have seriously interfered with the preparation of the ground and seeding. The rain is, moreover, distributed over a comparatively few days during each month, so that there are usually sufficiently long intervals between two rainy periods to give the land opportunity to dry off.

Considering the temperature conditions during the four months in question (fig. 1), we see that during December and the early part of January the land is liable to remain wet much longer than at other times because of the low temperatures. During early November the weather is comparatively warm, and after the middle of January the temperature rises again and the land dries readily. February rains offer the least difficulty, usually.

In order to take advantage of the clear, dry days for planting, all the major operations on the seed bed must be completed before the fall rains begin so that during the dry spells only the lighter operations, such as disking, weed cutting, and harrowing, need to be done.

Summarizing the information gained from experience with commercial plantings, we may state that late December, January, and the first part of February are particularly favorable months for planting sugar beets in central California.

TIME OF PLANTING AND THE CURLY-TOP DISEASE

The time of planting is very important from the standpoint of minimizing injury from the curly-top disease, which is one of the main limiting factors in the culture of sugar beets in California. As has been shown by Carsner and Stahl,⁴ the beet is most susceptible to this disease at its early stages of growth. When it has attained a fairly large size, it suffers much less injury from curly top. Consequently, the beets must be planted at such a time that they will be past their susceptible stage when the disease appears in the field.

The curly-top disease is spread solely by the beet leafhopper, *Eutettix tenellus* (Baker). Severin,⁵ who has made very extensive studies of the life history of this insect, has shown that beet leafhoppers overwinter upon pasture vegetation in the plains and foothills of the semi-arid sections of California. They fly to the cultivated areas in the spring during late March to May, according to the season and locality. The leafhoppers prefer sugar beets to the other economic plants, lay their eggs there, and breed there for two generations. The leafhoppers of the overwintering generation leave the cultivated areas and fly to the foothills during October and November. Consequently, the beet grower has the time from December until February during which his fields are free from the disease-carrying beet leafhoppers, so that beets planted from late November until about the middle of February attain a large size by the time curly top appears in the fields and usually escape severe injury from the disease.

In some years, and in certain areas, the fall-planted beets may be injured by the so-called 'stragglers'—overwintering leafhoppers which remain in the cultivated areas after the main body of insects have made their return flights to the foothills. Such was the case in 1918–1919 in the San Joaquin and Salinas valleys. During the autumn the saltbushes and other favorable wild host plants of the leafhopper in these valleys become dry, so that the overwintering generation does not find any food in the cultivated areas after the beets are harvested. The adults fly to the plains and foothills and the nymphs perish. In the fall of 1918, however, unusually early rains fell, namely on September 11–13, and a new growth of weeds developed in the cultivated areas. The nymphs which hatched from eggs deposited in the fall by the females of the summer generation now

⁴ Carsner, E., and C. F. Stahl. Studies on curly-top disease of the sugar beet. Jour. Agr. Res. 28:297–319. 1924.

⁵ Severin, H. H. P. Life history of beet leafhopper, *Eutettix tenellus* (Baker), in California. Univ. Calif. Pubs. Ent. 5:37–88. 1930.

found an abundance of food in this new growth of vegetation in the cultivated districts. They acquired the winged stage subsequent to the autumnal return flights of the overwintering adults to the foothills, and remained behind in the cultivated areas in the northern San Joaquin and in the upper Salinas valleys. During the winter these stragglers congregated upon the early-planted beets, and as a result of this, one-half of the 1919 crop showed symptoms of curly top before the spring generation flew from the foothills into the cultivated regions during April.

In years when no large amount of green vegetation is available in the cultivated areas during a dry autumn, the number of stragglers is greatly reduced and the percentage of curly top is consequently very low during the winter in early-planted fields. Observations made during 1917-1921 showed the following percentages of curly top in early-planted beets in the northern San Joaquin Valley: in 1917-18, 4 per cent; 1918-19, 50 per cent; 1919-20, 0.01 per cent; and 1920-21, 5 per cent.

Considering the possibility of straggler injury in the San Joaquin Valley, beets should not be planted here earlier than December. As to late plantings, those of March and April, they do not make profitable crops in this valley, except in years of unusually light outbreaks of curly top.

In the Sacramento Valley the overwintering beet leafhoppers are exterminated in the cultivated areas and on the foothills of the Coast Range owing to climatic conditions. There has never been a case of curly top observed in the early-planted beet fields until after the migration flights occurred from the San Joaquin Valley. For this reason, plantings may be done somewhat earlier in the Sacramento than in the San Joaquin Valley, that is in November. After a serious outbreak of curly top, however, as occurred in 1919 and 1925, beets should not be planted until the end of November, because large numbers of leafhoppers often congregate and stay for some time on favorable weeds after the beets are harvested and move into the fields of young beets when these come up. During years of outbreaks beets should not be planted later than February. On the other hand, in years when the disease is not severe good tonnages are usually obtained from March and April plantings in the Delta region of the Sacramento Valley.

In the Salinas Valley, also, the practice of planting sugar beets early has been recognized as a means of reducing damage from the curly-top disease, especially outside the fog belt between Soledad and

King City. Here beets should be planted from the end of November to the middle of February. In some years it would be unsafe to plant earlier on account of danger of injury by stragglers. In the fog belt, from Gonzales to the Monterey Bay, planting should be discontinued from March 1 until after the spring flights of the beet leafhoppers cease, so that there will be no young beets when the insects arrive in the fields. Late plantings in May and June in the fog belt usually result in a good crop, except in years like 1925, when a partial second brood developed in the foothills so that a second flight into the cultivated areas occurred during late spring and early summer.

In the San Juan Valley the planting schedule should be followed as described for the fog belt of the Salinas Valley.

BOLTING IN SUGAR BEETS

One of the difficulties encountered in the culture of very early-planted beets in California is bolting—that is, the sending out of seed stalks during the first year of growth of the plant (fig. 2).

Conditions that cause bolting have not yet been definitely determined; but bolting is known to be an inherent characteristic of a complex nature, strongly influenced by environmental conditions, of which climatic factors are of primary importance. Most workers believe that a prolonged interruption of growth through cold weather (not necessarily through frost) is the main factor inducing bolting in sugar beets.

The Davis experiments support the contention that climatic conditions affect the tendency of beets to bolt. First, the percentage of seed stalks varied considerably from season to season as shown in table 1. In 1930–31, the warmest of the four seasons that were under observation in Davis (fig. 1), the percentage of bolting was lowest. Secondly, beets that were planted in the late fall and were exposed to cold temperatures for a long time showed a higher percentage of bolters than beets that were planted later, when the weather became warmer. Thirdly, beets that were grown on the north side of ridges showed a higher percentage of bolters than those grown on the south sides. This latter point requires a more detailed consideration.

As was mentioned before, in 1930–31 the beets were grown on ridges. These ridges were oriented east and west, and it was apparent that the beets on the south side of the ridges received more sunshine and heat than those on the north side. This fact was shown by the marked difference in the development of the plants on the two sides

of the ridges. Table 4 and figure 3 give the results obtained in this trial.

The north exposure brought about a reduction in the average weight of roots and an increase in percentage of bolting. There was no reduction in the percentage of sugar on the north side. In fact, the beets on the south side tested somewhat lower than those on the north side, probably because the former were larger. The total yield

TABLE 4
DIFFERENCE IN YIELD BETWEEN BEETS GROWN ON NORTH AND SOUTH SIDES
OF RIDGES; 1930-31, DAVIS, CALIFORNIA

		Date of planting					
		Oct. 16	Nov. 18	Dec. 15	Jan. 15	Feb. 17	Mar. 14
Date up.....	{ North South	Oct. 23	Dec. 4	Jan. 15	Feb. 2	Mar. 2	Mar. 23
		Oct. 23	Dec. 3	Jan. 10	Jan. 31	Mar. 2	Mar. 23
Number of beets harvested per 100 feet of row.....	{ North South	108	91	92	101	105	95
		106	101	98	102	103	106
Percentage of bolters.....	{ North South	37.6	20.8	9.5	1.1	0	0
		22.7	12.3	6.5	0 0	0	0
Average weight per beet, pounds.....	{ North South	2.1	1.8	1.8	1.9	1.4	1.4
		2.7	2.7	2.7	2.2	1.7	1.3
Percentage of sugar.....	{ North South	18.1	18.2	19.4	18.8	18.3	18.1
		16.8	17.8	18.9	17.9	17.9	18.3
Yield of roots, tons per acre.....	{ North South	29.5	21.0	21.8	24.9	19.9	17.2
		37.6	35.2	34.8	28.8	22.5	17.6
Yield of sugar, pounds per acre.....	{ North South	10,679	7,644	8,458	9,362	7,283	6,226
		12,634	12,531	13,154	10,310	8,055	6,442

of roots and sugar was higher on the south side, where the seed germinated more rapidly and where the percentage of bolters was lower than on the north side. This seems to indicate that conditions which brought about the reduction in size of roots on the north side were favorable to bolting.

It has been observed in commercial fields also that sometimes yields were low in fields that showed a high percentage of bolting. Such was the case in 1927 when December plantings showed 70 per cent bolters and gave only 8.20 tons per acre, as compared with 21.17 tons in January beets in which bolting was much less (table 2).

It is, however, not the rule that fields showing a considerable degree of bolting give low tonnages. Growers generally believe that

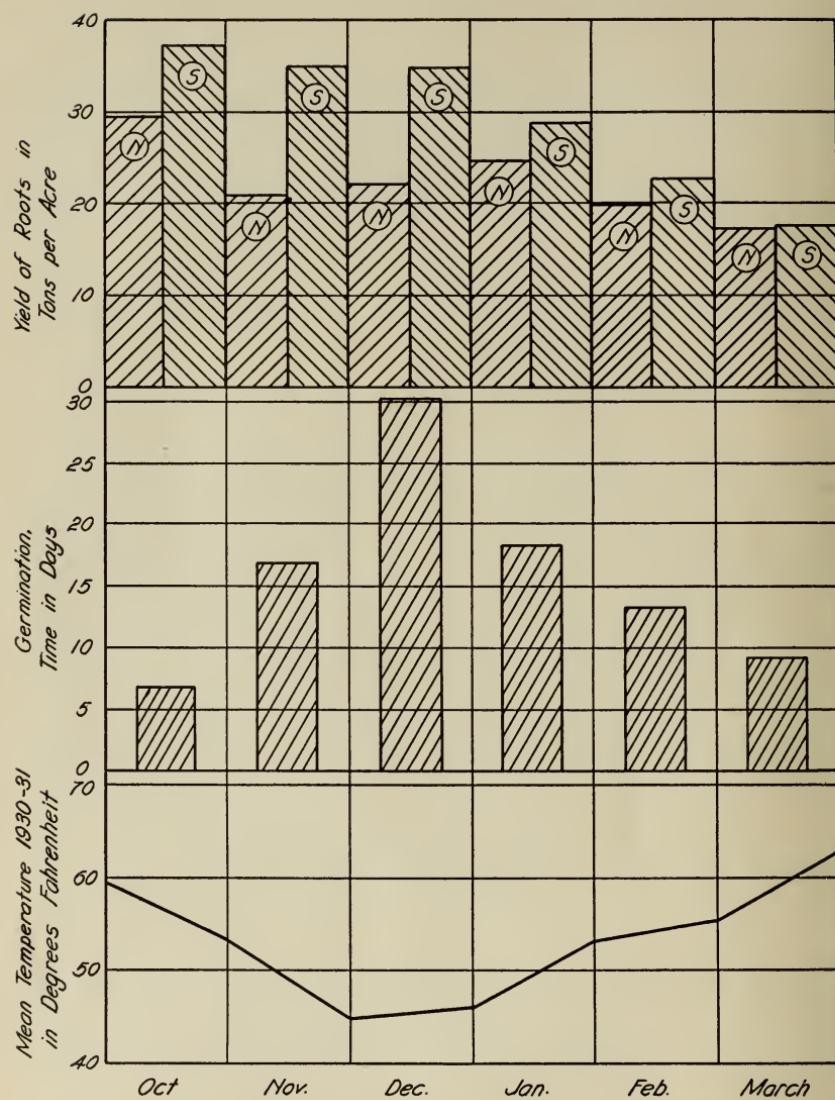


Fig. 3.—The upper graph shows the difference in yield of roots on the north (N) and south (S) sides of ridges for each month of planting. The middle graph shows the time interval in days between the date of planting and the date of emergence of the seedlings above the surface of the ground. The lower graph shows the mean monthly temperatures for 1930-31.

bolters have roots much inferior to normal beets. This supposition is true under some conditions; in other cases, bolters may have roots as heavy in weight and as high in sugar and purity as normal beets.

The degree of bolting varies with seasons; and within the same year seed stalks do not all develop at the same time, but appear gradually throughout the spring and summer. For this reason the quality of bolters as compared with normal beets varies considerably. The later the bolters appear, the less will be the effect upon the root, and the less will be the difference between the normal beets and the bolters.

TABLE 5
BOLTERS COMPARED WITH NORMAL BEETS

Date planted	Date harvested	Bolters			Normal beets		
		Number of beets in sample	Weight per beet, pounds	Percentage of sugar	Number of beets in sample	Weight per beet, pounds	Percentage of sugar
Davis, Yolo County							
Nov. 11, 1930	Aug. 31, 1931	5	2.3	16.1	5	1.6	16.6
		4	2.1	18.6	4	2.4	16.6
		4	2.6	16.9	4	1.8	17.2
		3	2.4	15.4	3	2.5	16.7
		4	3.1	16.6	4	3.4	16.5
		<i>Average</i>		2.5	16.7	...	16.7
Staten Island, Sacramento County							
Jan. 18, 1930	Aug. 29, 1931	9	1.4	15.5	10	1.5	14.6
		10	1.2	17.4	9	2.0	17.3
		10	1.9	15.7	10	0.8	17.2
		10	1.5	15.1	10	1.9	15.2
		10	2.5	17.4	10	1.6	17.0
		10	2.2	14.7	10	1.2	17.0
Jan. 18, 1930	Aug. 31, 1931	<i>Average</i>		1.8	16.0	...	16.3
		15	2.1	14.6	15	1.6	14.7

In some European countries beets planted in March may in some years be affected by late frosts. Such fields have been reported to produce a high percentage of bolters with roots of very low quality, which remain small and spindly, have a low sugar content, and are extremely woody. As the seed stalks usually begin to appear in May, the March beets have still comparatively small roots at that time; and apparently the sending out of a seed stalk at an early stage of development of a beet plant checks the increase in size of root, all the energy being utilized for the production of flowers and seed.

A different situation is encountered under California conditions. The early plantings (October to December, inclusive) have a pronounced tendency to go to seed before the season is over; but these beets usually grow to a considerable size before the flower stalk is sent up, in May or thereabouts. For this reason the yield and percentage of sugar are frequently not materially affected by bolting under California conditions.

Table 5 gives the results of analyses of bolters and of normal beets from different plantings in the Sacramento Valley. In the table are given pairs of samples of normal and bolting beets which were growing in immediate proximity to each other in the field. On the average, there is practically no difference in the weight of the roots and the percentage of sugar in the two kinds of beets. The bolters were not inferior to normal beets with regard to purity of juices. The purity coefficient of the Davis samples was 84.2 in bolters and 84.2 in normal beets; in Staten Island samples 85.7 in bolters, 84.6 in normal beets.

From the grower's viewpoint, one of the serious objections to bolting is the fact that the tough, woody seed stalks interfere with the harvest operations. In extreme cases, seed stalks are in the way of the beet-lifting machinery and must be mowed before the plowing can be started. Bolters are more difficult to top than normal beets and dull the knives much more. It has been observed that the topping crew sometimes shows the tendency to discard bolters, so that losses in yield occur.

The cutting of the seed stalks during the growing season is not to be recommended. The beet will make other stalks if the first one is removed, so that this operation must be repeated and becomes expensive.

Bolting beets are also objectionable from a manufacturing standpoint, because of their woody fibrous roots, which dull the knives in the cutters very rapidly.

To sum up: Bolting in commercial fields becomes a serious objectionable feature in years when its percentage is very high and when the development of the seed stalks begins very early. In other seasons difficulties presented by the bolters are not serious and are more than compensated for by high yields of sugar and by the safety of the crop in early-planted beets.

SUMMARY AND CONCLUSIONS

Early planting of sugar beets is recommended for central California in preference to late spring plantings. By early plantings are meant those beginning about the middle of November and completed not later than the end of February.

Late plantings have the following disadvantages: The plants have a short growing season and do not attain as large a size as early-planted beets. It is frequently difficult to obtain good stands in spring and early summer because of lack of moisture, dry winds and high temperatures. Late-planted beets in years of outbreaks of curly top are exposed to a very severe infection.

Early-planted beets, on the other hand, have a long growing season. Since they are comparatively large at the time when climatic conditions permit the most rapid growth (spring and early summer) they take the fullest advantage of these conditions and their rate of increase at this time is higher than that of the still small late-planted beets.

The early plantings get the benefit of the winter rains to a higher degree than late plantings; and the beets make the major part of their growth during cool weather, which is beneficial to the development of the plant.

Beets planted early have attained considerable size at the time they are infected with curly top; hence they are relatively resistant to this disease and the damage caused by curly top is materially reduced.

When beets are planted early, more time is available for reseeding in the case of stand failures.

Considering the late fall (November–December) and winter (January–February) plantings separately, experience has shown that January and February are generally more favorable months for planting sugar-beet seed than November and early December. A number of difficulties may be encountered in late fall plantings.

It is frequently difficult to obtain good stands in late fall. The seed germinates slowly in the cold ground and if a crust is formed the seedlings have no power to penetrate to the light. Or, on the other hand, heavy rains may drown out the slowly growing young plants. Stands may also be materially reduced by damping off, especially in heavy soils with poor drainage. Frost may injure the plants that are just emerging above the surface of the ground.

November and December plantings produce bolters, and this feature may in some years become seriously objectionable. Bolters frequently yield woody fibrous roots, and the seed stalks cause difficulties during harvest time. The yield and percentage of sugar are apparently not materially affected by bolting under California conditions, when the percentage of bolters is not extremely high and the seed stalks do not appear too early.

The period between early January and the end of February, on the other hand, is usually very favorable for planting, because at that time the temperature rises; the soil becomes warmer; the seed germinates rapidly; and the plants grow fast, give good yield of roots and sugar, and produce few or no bolters. The January and February plantings frequently give more sugar to the acre than the November and December plantings because of the higher percentage of sugar combined with good yield of roots.

In conclusion: Late December, January, and first part of February are recommended as particularly favorable months for planting sugar beets in central California (San Joaquin, Sacramento, San Juan, and Salinas valleys).

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